Status of US Navy Ship Airwake CFD Efforts

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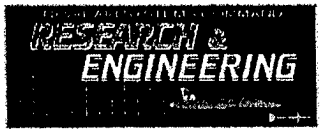
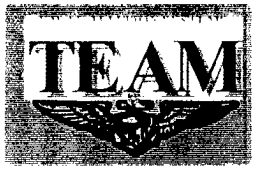
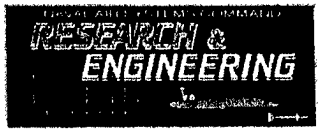
Outline



- Brief Review of Physics
- The Ideal CFD Code Validation Experiment
- Generic Frigate Results
- LHA Results

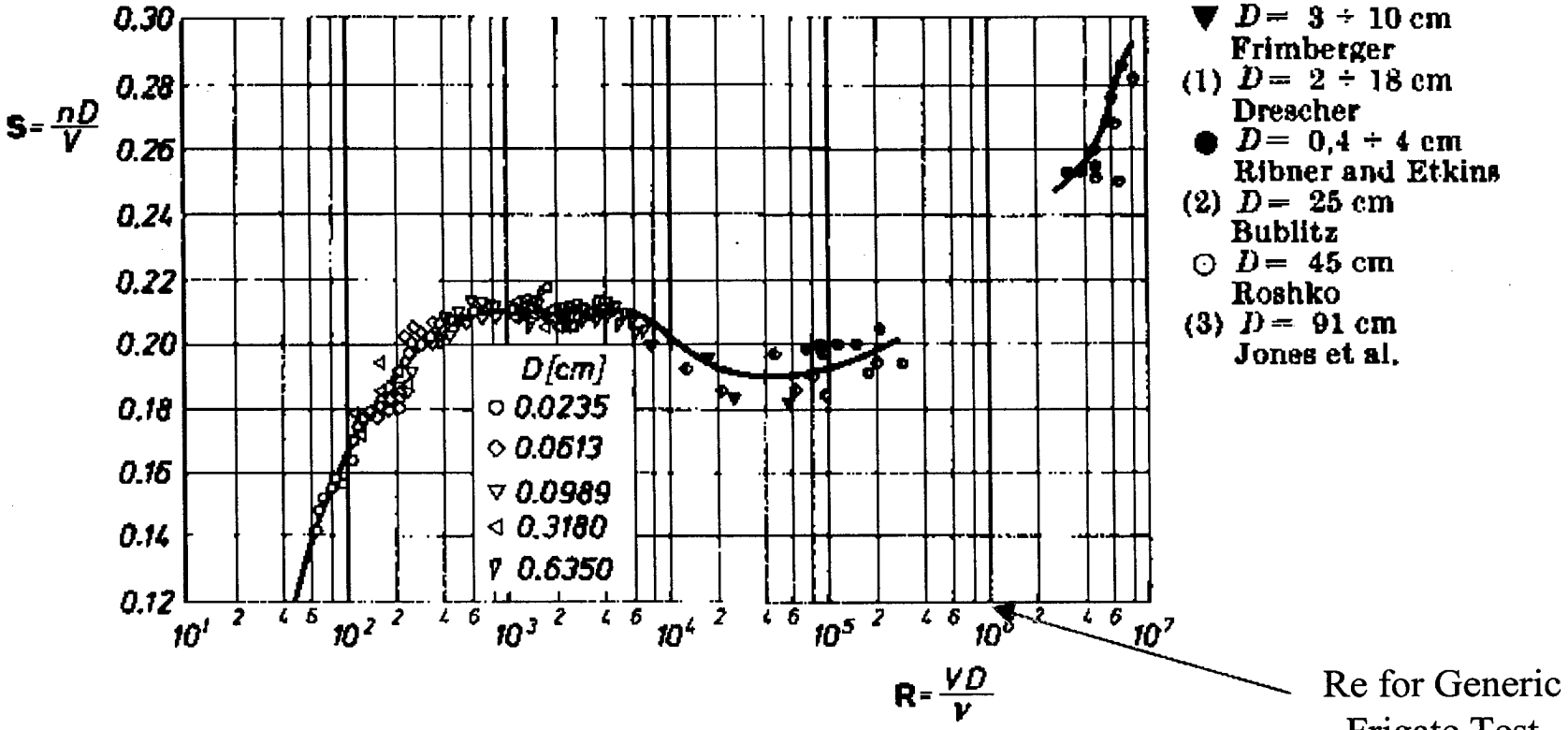


Simple Geometry, Complex Physics

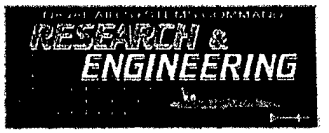


- Wake-dominated
- Strong Vortices
- Vortex Shedding
  - may be periodic, or not, depending on Reynolds number
- Data for full-scale Re is extremely hard to find (Bruce Johnson @ USNA?)

Schlichting Data for a Circular Cylinder



The Ideal CFD Code Validation Experiment

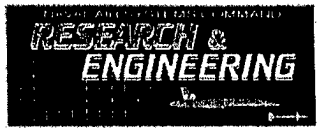


- Detailed Measurement of Boundary Conditions
  - inlet velocity profile
  - outlet pressure map
  - wall boundary layer measurements
- Redundant Data Measurements, e.g.,
  - LDV + pitot-static
  - taps + Kulites

Conclusions from Physics

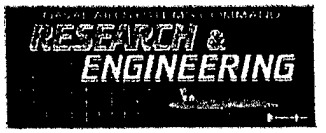
- Experiments Should
  - include unsteady measurements
  - include off-body measurements

Ideal Validation Experiment (cont.)



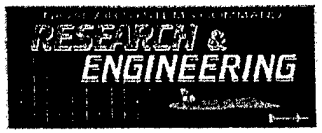
- Data Uncorrected for Wall, BL, Wake Effects
- Off-body Measurements

Pretty Good Validation Experiment



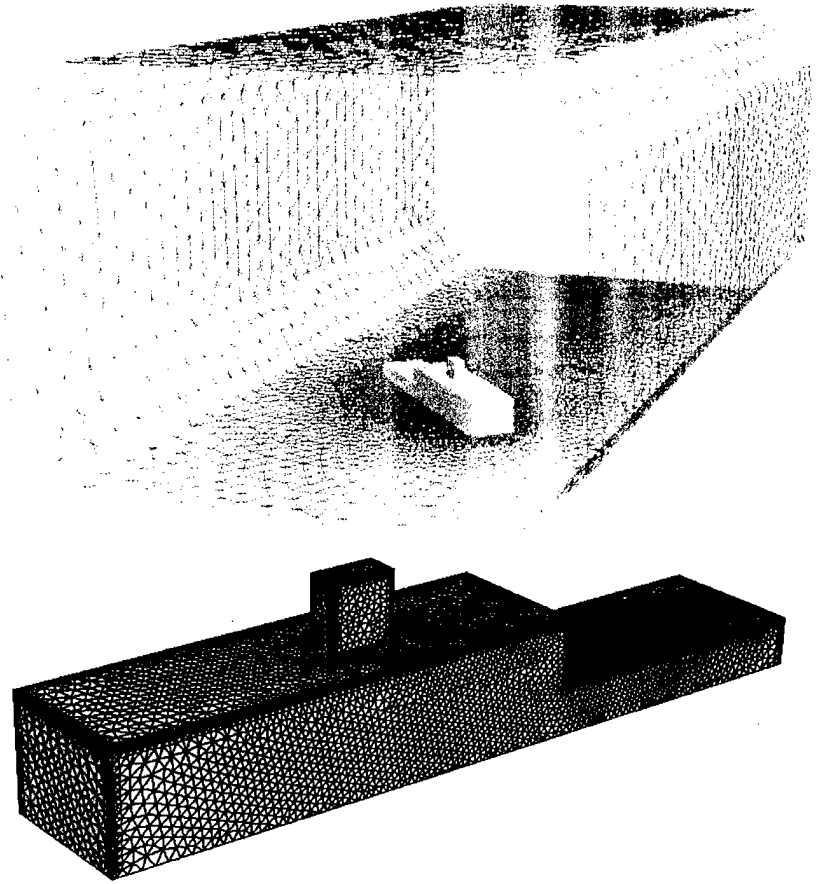
- NOT corrected for model or wake blockage (we can run with walls)
- Corrected for Tunnel Wall BL (so those walls can be inviscid)
- Some off-body data
- Unsteady surface pressures

Generic Frigate Results

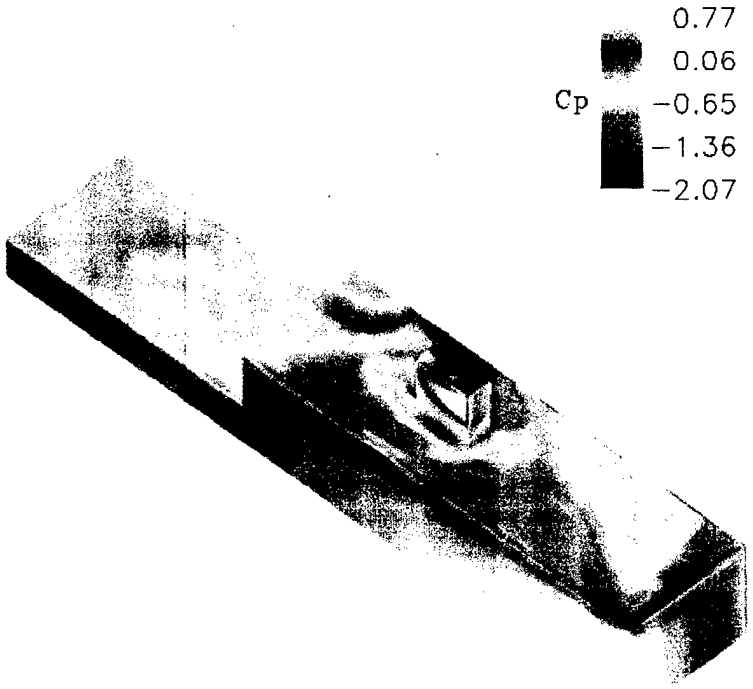


- Both structured and unstructured runs completed
  - in tunnel
  - free air
- Concentrated on 45° case, but have some 0° results as well

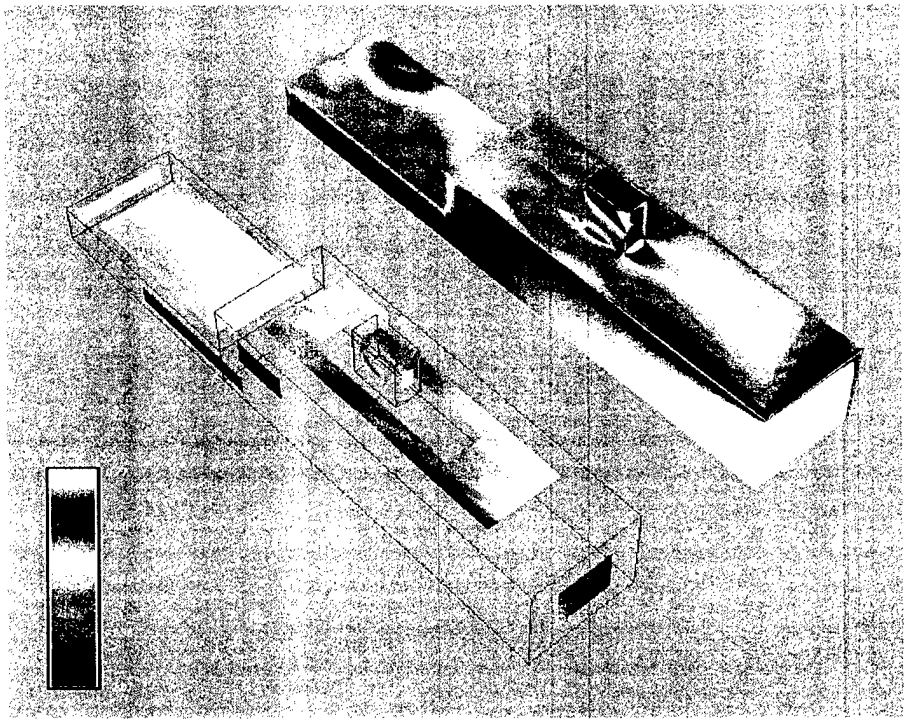
Generic Frigate Grids



Generic Frigate Pressure Coefficient Contours

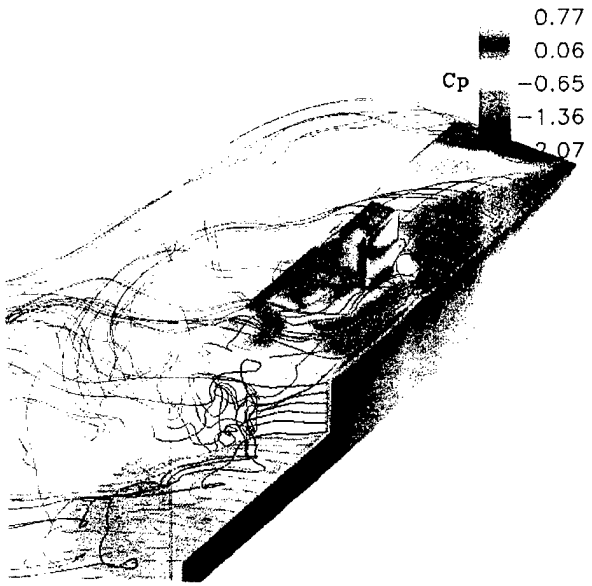


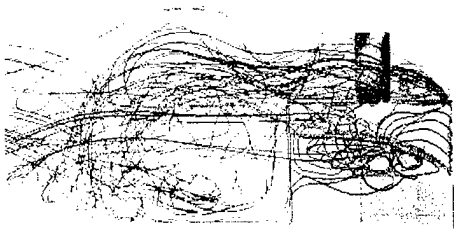
Unsteady laminar solution (snapshot)

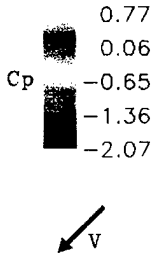


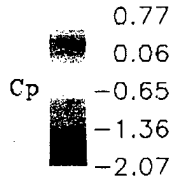
Steady laminar solution w/experimental data

Generic Frigate Streamlines

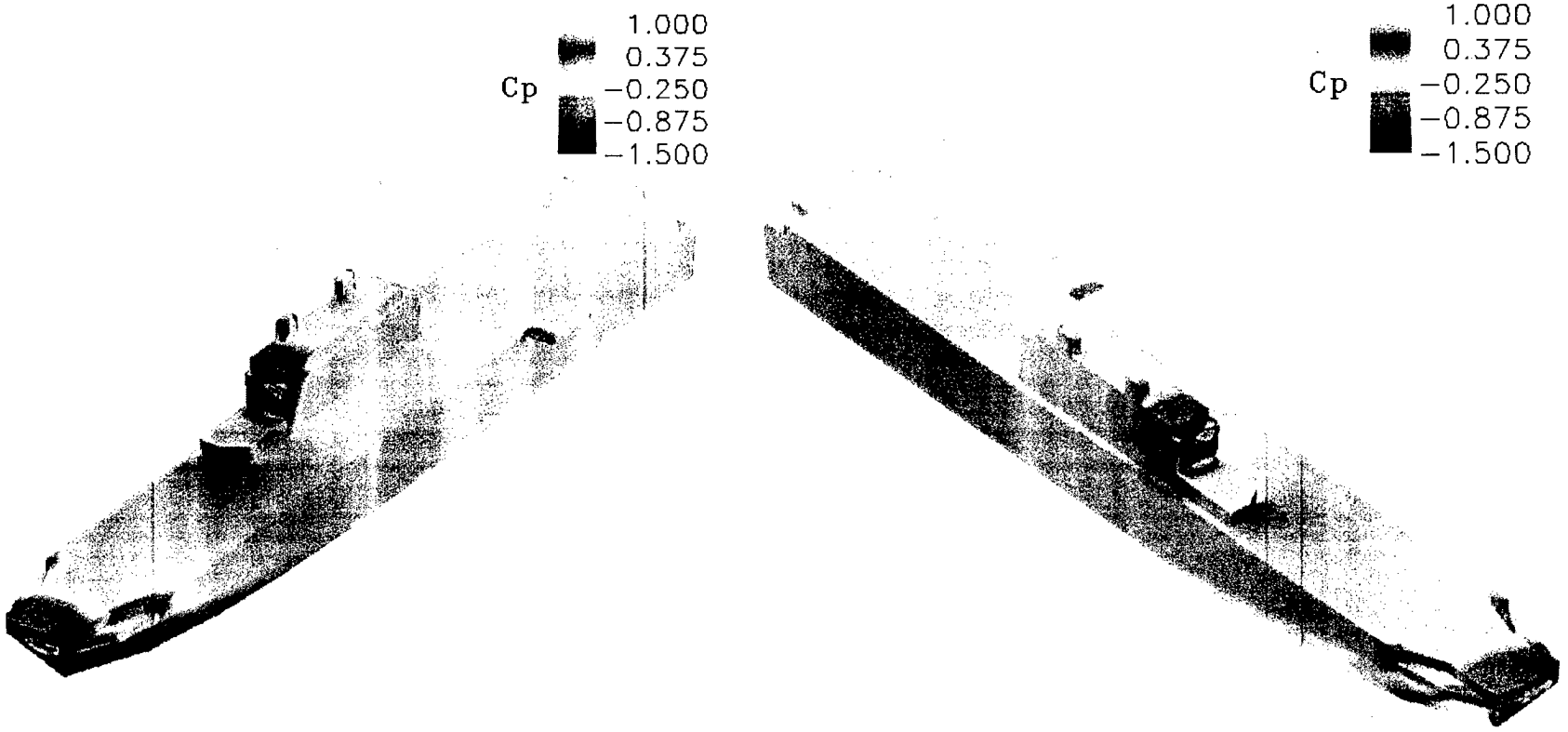




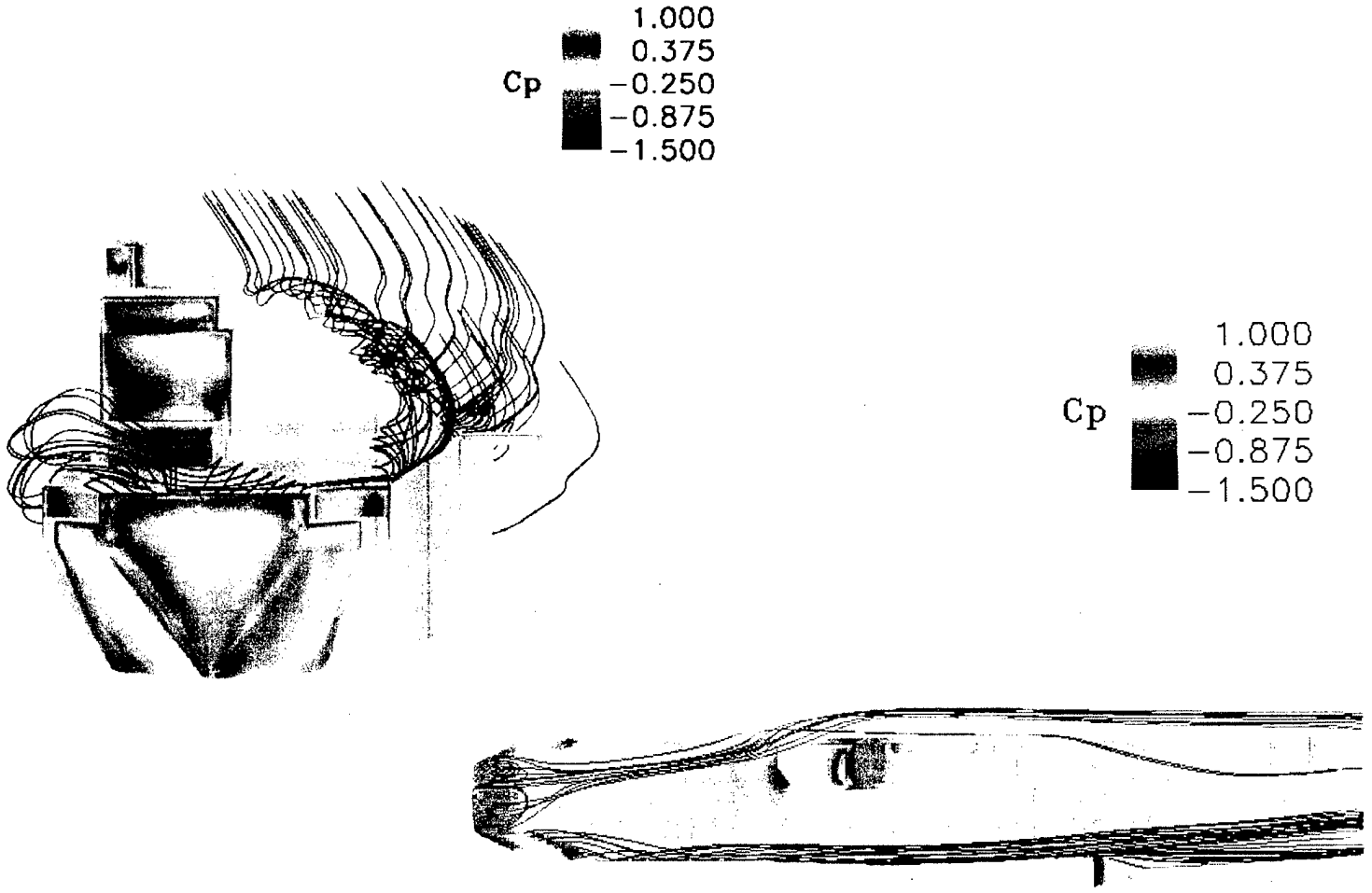




LHA Pressure Coefficient Contours

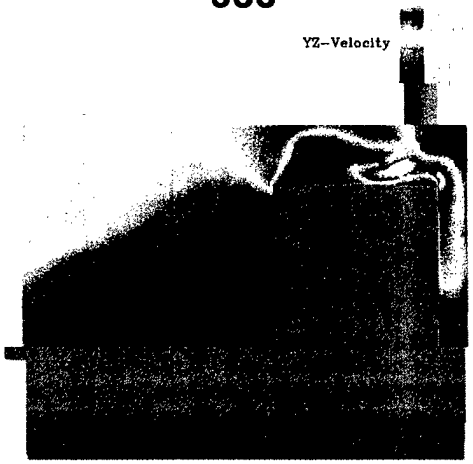


LHA Streamlines

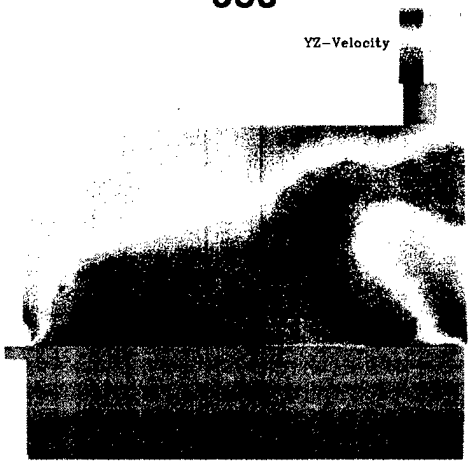


LHA Crossflow Velocity Countours

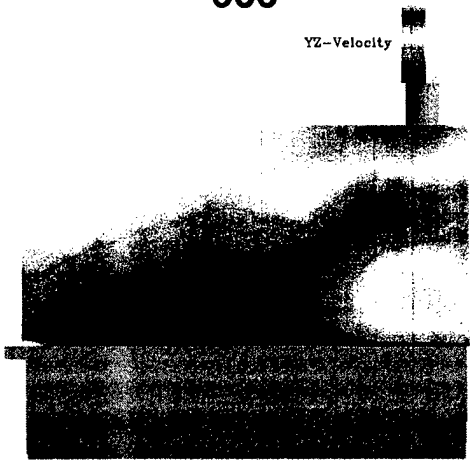
533'



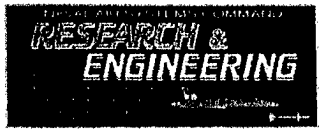
583'



633'



Conclusions



- Unsteady computations are necessary to capture flow physics
  - flow is inherently unsteady
- Rotor modeling critical to computing hover flight conditions
  - crossflow velocities much smaller than rotor downwash, but a LOT of fluid is affected
- Full-scale Reynolds number testing is needed